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Superfund: Research, Development, and Demonstration Strategy and Program Plan

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16. ABSTRACT

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The Superfund RD&D program is generally structured to conform with the Agency's risk-assessment and risk-management decision process. This research framework mirrors the procedures used in the Superfund Program: assessments are conducted at each site to determine specific health and ecological risks; then, if needed, options are formulated and evaluated to determine what remedial actions can be taken to reduce the risk to acceptable levels. Risk managers rely on this scientific and technical information to make cleanup decisions.

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Office of Research and Development
U.S. Environmental Protection Agency

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PREFACE

The Superfund Amendments and Reauthorization Act of 1986 (SARA) explicitly authorized the Environmental Protection Agency, in concert with several other agencies, to conduct hazardous waste research, development, and demonstrations and to aggressively pursue a program of technology transfer and training.

EPA's Office of Research and Development, working with representatives of the Office of Solid Waste and Emergency Response, Regions, States, and other federal agencies, has developed this research strategy as the most appropriate course to follow over the next few years.

EPA's research programs are governed by a policy of risk management, which combines qualitative and quantitative aspects of risk assessment with risk avoidance and risk reduction. In addition, the Agency maintains a strong program of technical support, principally focused on Regional, state and local government audiences concerned with regulations, permits, and enforcement. Risk management is therefore the endpoint around which the Superfund Research Strategy is built.

TABLE OF ACRONYMS

AEERL	Air and Engineering Research Laboratory
ATSDR	Agency for Toxic Substances and Disease Registry
CEPP	Chemical Emergency Preparedness [Staff; OSWER]
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [= Superfund]
CLP	Contract Laboratory Program
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
HERL	Health Effects Research Laboratory
HHS	U.S. Department of Health and Human Services
HWERL	Hazardous Waste Engineering Research Laboratory
HSWA	Hazardous and Solid Waste Amendments of 1986
IRIS	Integrated Risk Information System
LOEL	Lowest Observed Effects Level
NIEHS	National Institutes of Environmental Health Sciences
NOEL	No Observed Effects Level
OADEMQA	Office of Acid Deposition, Environmental Monitoring, and Quality Assurance [ORD]
OEETD	Office of Environmental Engineering and Technology Demonstration [ORD]
OEPER	Office of Environmental Processes and Effects Research [ORD]
OERR	Office of Emergency and Remedial Response [OSWER]
OHEA	Office of Health and Environmental Assessment [ORD]
OHR	Office of Health Research [ORD]
OPA	Office of Policy Analysis [ORD]
OPMT	Office of Program Management and Technology [OSWER]
OPP	Office of Pesticide Programs [OPTS]
OPPE	Office of Policy, Planning, and Evaluation
OPTS	Office of Pesticides and Toxic Substances
ORD	Office of Research and Development
ORPM	Office of Research Program Management [ORD]
OSW	Office of Solid Waste [OSWER]
OSWER	Office of Solid Waste and Emergency Response
OUST	Office of Underground Storage Tanks [OSWER]
OWPE	Office of Waste Programs Enforcement [OSWER]
PCS	Program Coordination Staff [ORD]
PPA	Planned Program Activity
PRP	Potentially Responsible Party
QA/QC	Quality Assurance/Quality Control
RAC	Risk Assessment Council
RCRA	Resource Conservation and Recovery Act of 1976
RD&D	Research, Development, and Demonstration
RFA	Request for Applications
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
SAR	Structure Activity Relationship
SARA	Superfund Amendments and Reauthorization Act of 1986
SITE	Superfund Innovative Technology Evaluation
T&E	Test and Evaluation
USGS	United States Geological Survey
VOC	Volatile Organic Compound

1. INTRODUCTION

This research, development, and demonstration (RD&D) strategy not only describes the Office of Research and Development (ORD) Superfund research program but other ORD support relevant to the Superfund program mission. It is intended to guide the Superfund Office and the Agency in setting research priorities and allocating resources; to aid in coordination among Federal agencies that conduct Superfund-related research; and to assist ORD scientists and engineers in understanding the programmatic context of their work. Covering the five-year period FY87 through FY91, the strategy comprises all Superfund research work undertaken by the ORD offices and laboratories, and refers to related research conducted by ORD under other statutes.

The Superfund RD&D program is generally structured to conform with the Agency's risk-assessment and risk-management decision process. This research framework mirrors the procedures used in the Superfund Program: assessments are conducted at each site to determine specific health and ecological risks; then, if needed, options are formulated and evaluated to determine what remedial actions can be taken to reduce the risk to acceptable levels. Risk managers rely on this scientific and technical information to make cleanup decisions.

1.1 Background

The original Superfund law—the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)—was envisioned as a cleanup effort that would use existing knowledge to assess and clean up the nation's abandoned hazardous waste sites. That attitude has changed markedly. It is now widely recognized that better tools and information are needed to assess risks at sites, to understand potential effects on human health and the environment, and to provide reliable cleanup solutions.

CERCLA did not explicitly authorize research and development activities. However, ORD provided extensive technical support to the Superfund program in several areas, including development of techniques and procedures needed to assess sites and situations; evaluation of technologies to manage uncontrolled waste sites; information and procedures on personnel protection technologies; direct technical assistance to enforcement and Superfund offices, and the EPA regional offices; and technical oversight of data quality assurance.

The Superfund Amendments and Reauthorization Act of 1986 (SARA) was signed by President Reagan on October 17, 1986. The amendments made major changes to the original Superfund law, including strict cleanup standards strongly favoring permanent remedies at waste sites, stronger EPA control in settlement with parties responsible for waste sites, a mandatory schedule for initiation of cleanup work and studies, assessment of the potential threats to human health posed by each waste site, and increased state and public involvement in the cleanup decisionmaking process.

In particular, two SARA requirements directly affect research priorities: the need for better assessment of health risks posed by Superfund sites and treatment technologies that offer permanent protection of human health and the environment. The new requirements on cleanup standards illustrate the statutory intent in these areas. SARA requires that remedial actions protect human health and the environment, be cost-effective, and be in accordance with the requirements of the National Contingency Plan. They must use, to the maximum extent practical, permanent solutions and alternative treatment or resource recovery technologies. Each technology must be evaluated to determine its long-term effectiveness. Finally, remedial actions must attain the legally applicable Federal and State standards, requirements, criteria, or limitations. If a remedial action results in any hazardous substance remaining on site, the remedy must be reviewed at least every five years and, if needed, additional action must be taken to ensure the protection of human health and the environment.

1.2 New Research Mandates

To help achieve these ambitious goals, SARA adds the following major new authorities for RD&D in EPA and other Federal agencies:

- Section 209 of SARA amends CERCLA by adding a §311(b), which authorizes an EPA program of research, evaluation, testing, development, and demonstration of alternative or innovative treatment technologies that may be utilized in response actions to achieve more permanent protection of human health and welfare and the environment.

- Section 209 [now §311(c)] authorizes EPA to conduct and support, through grants, cooperative agreements, and contracts, research on the detection, assessment, and evaluation of the effects and risks to human health from hazardous substances and detection of hazardous substances in the environment.

- Section 209 [now §311(d)] authorizes the establishment by EPA of up to 10 hazardous substance research centers to conduct research and provide training on the manufacture, use, transportation, disposal, and management of hazardous substances, and publication and dissemination of the results.

- Section 110 [now §104(i)] authorizes a research program at the Agency for Toxic Substances and Disease Registry to develop appropriate methods to determine the health effects of hazardous substances frequently found at Superfund sites. In addition to programmatic responsibility, research at ATSDR shall seek to develop methods to determine the health effects of such substances in combination with other substances (complex mixtures).

- Section 209 [now §311(a)] authorizes a program at the National Institute for Environmental Health Sciences (NIEHS) to develop advanced techniques for detection and evaluation of the effects on human health of hazardous substances; methods to assess the risks to human health presented by hazardous substances; methods and technologies to detect hazardous substances in the environment; and basic biological, chemical, and physical methods to reduce the amount and toxicity of hazardous substances.

- Section 211 amends Title 10 of the United States Code (Chapter 160, Environmental Restoration) and authorizes the Secretary of Defense to carry out a program of research, development and demonstration with respect to hazardous waste. The Department of Defense program is directed towards a reduction in the quantities of hazardous wastes; methods for treatment, disposal, and management (including recycling and detoxification); identification of more cost-effective cleanup technologies; toxicological data collection and methodology on risk of exposure; and the testing, evaluation, and field demonstration of innovative technologies.

2. RESEARCH FRAMEWORK

The overall objective of the Superfund RD&D program is to improve the technical and scientific basis of the Agency's risk management decisions at uncontrolled hazardous waste sites.

The Superfund RD&D program in ORD will improve the risk assessment and risk reduction capabilities of the program offices, Regions, States, and potentially responsible parties (PRPs), and will help ensure that effective cleanup solutions are implemented. A viable research program depends upon strong in-house research expertise and state-of-the-art research facilities. This expertise can then support the cleanup and enforcement activities of Superfund through guidance and technical leadership. This chapter lays out the rationale and structure of ORD's research strategy, and shows how the research issues fit within the overall risk management framework of the Agency. Subsequent chapters describe each research segment in detail.

2.1 Research Issues

The Superfund research program addresses nine broad technical issues (Table 1) that represent the needs of the Superfund Office and are used as a framework for planning, budgeting, and justifying the RD&D program.

Table 1. Superfund Research Issues

ISSUE	OBJECTIVE
Site and Situation Assessment	Provide techniques and procedures to allow on-scene coordinators to quickly and effectively assess the degree of hazard posed at specific sites.
Health Effects and Risk Assessment	Conduct research and development to detect and evaluate risks and effects on human health from hazardous substances.
Technology Evaluation	Assess the technologies, techniques, and construction materials that may provide cost-effective control of hazardous releases.
Innovative and Alternative Technology RD&D	Conduct research, development, and demonstration that promote commercialization of alternative treatment and monitoring technologies.
Personnel Protective Equipment	Evaluate technologies needed to ensure personnel health and safety during removal and cleanup operations.
Reportable Quantities	Provide information on carcinogenicity or chronic health effects needed by OERR to adjust reportable quantities for specific chemicals.
Technical Support	Review remedial action design and implementation plans, and provide technical expertise and review to OERR and OWPE.
Quality Assurance	Provide oversight to the national Contract Laboratory Program, and develop analytical methods for chemical measurements and characterization; review QA/QC plans.
Technology Transfer	Transmit information to OERR, Regions, States, and local authorities to assist in site cleanup.

These nine technical issues may be grouped within two mission-oriented categories that together support the risk assessment and risk reduction approach used by the Superfund Office.

- RD&D includes the basic and applied research and development program and the technology demonstration program. It results in new or improved data bases, risk assessment methods, detection methods for hazardous substances, and control technologies. RD&D is subdivided into risk assessment research and risk reduction (control technology) research.

- Technical support involves direct assistance by ORD scientists and engineers. ORD maintains hazardous substances and alternative technology data bases, is responsible for the Integrated Risk Information System (IRIS), and provides support to the Risk Assessment Council and Risk Assessment Forum. ORD also provides the quality assurance program for the Contract Laboratory Program and remote sensing in support of site assessment and enforcement actions.

Figure 1 presents the distribution of resources among the research issues for FY88. In terms of technical discipline, engineering comprises about one-half of the total program; monitoring about one-quarter; and one-quarter is divided among environmental processes, scientific assessment, health effects, and exploratory research. Table 2 shows how each of the nine issues relates to the research

Figure 1. Superfund Research by Issue (FY 1988)

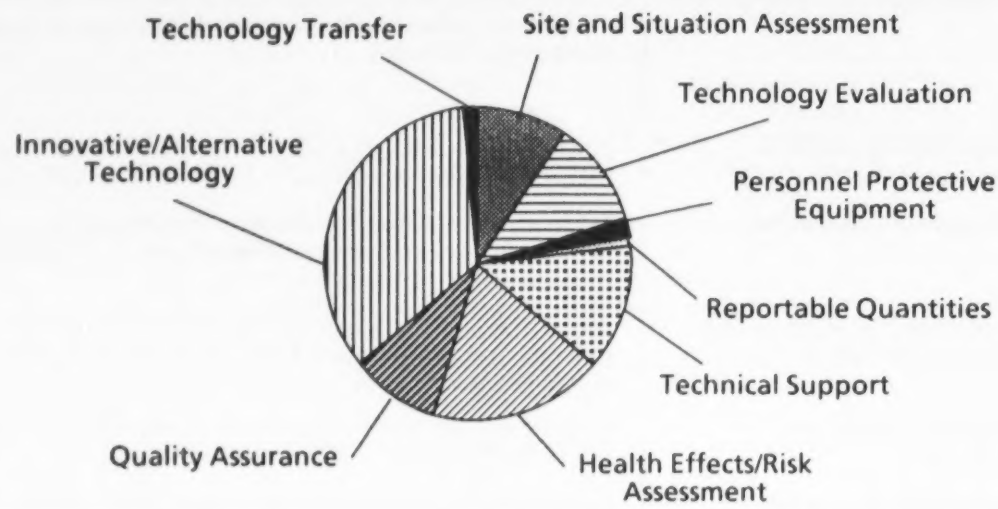

Table 2. Superfund Research Issues by Program Need

ISSUE	RD&D		TECHNICAL SUPPORT
	RISK ASSESSMENT	RISK REDUCTION	
Site and Situation Assessment	●		
Health Effects/Risk Assessment	●		
Technology Evaluation		●	
Innovative and Alternative Technology RD&D		●	
Personnel Protective Equipment		●	
Reportable Quantities			●
Technical Support			●
Quality Assurance			●
Technology Transfer	●	●	●

categories.

2.1.1 Risk Assessment Research

Two separate classes of studies are conducted under this category: human health risk assessment and ecological risk assessment. Assessments of risks to human health at Superfund sites are limited by information on chemicals present at a site, insufficient toxicological information on many of the known chemicals, and behavior of chemical mixtures. Currently, only four sets of guidelines for human health effects risk assessment exist: carcinogenicity; mutagenicity; chemical mixtures; and suspected developmental toxicants. These existing guidelines have served to define research needs that are now being addressed by various ORD activities. Interim guidelines for male and female reproductive risk assessment are scheduled for publication in the *Federal Register* in late fall of 1987. Future research will expand the methodologies to include reproductive and developmental effects, immunological effects, neurotoxic effects, and the effects on sensitive populations.

Additional procedures will be developed to ensure that the existing guidelines and any subsequent assessment methods are used appropriately. This will allow the general public and industry to understand EPA's risk assessment process, will provide an understanding of the uncertainties associated with risk assessment methods, and will result in clearer communication of risk to the public.

The long-term goal of the ecological risk assessment program is to develop procedures that will predict the ecological consequences from existing Superfund sites, including the long-term effectiveness of remedial actions. Currently, there are no uniform ecological risk assessment guidelines to ensure consistency for different Superfund sites. Ecological risk assessment research will improve current methods to account for environmental effects related to incremental dosage, compensate for differences between laboratory tests and actual field populations, include estimates of indirect effects of toxicants, improve predictive reliability, and improve the characterization of uncertainties. General approaches and procedures will be developed to ensure that ecological risk assessment methodologies are available for analyzing Superfund sites before, during, and after cleanup.

2.1.2 Risk Reduction Research

While human health and ecological risk assessments define existing or expected risks, implementation of control technologies actually mitigate or eliminate the risks associated with Superfund sites.

Superfund sites contain various hazardous chemicals and chemical mixtures, in several different forms: liquids, solids, gases, and sludges. The goal of risk reduction RD&D is to identify, evaluate and provide permanent treatment and containment technologies needed to clean up Superfund sites, including polluted aquifers.

The challenge is to provide effective control technologies that can treat complex mixtures in various forms and achieve very high risk reduction efficiencies for pollutants that are toxic at low concentrations without transferring those risks elsewhere.

2.1.3 Technical Support

The Superfund program is action-oriented. SARA establishes ambitious schedules for investigating and cleaning up Superfund sites. To help meet these schedules, ORD will provide comprehensive technical support to the Superfund and enforcement offices, Regional Offices, states, and private industry.

The major technical support activities utilize ORD's technical expertise and facilities to provide timely technical services, data and protocols, training and technology transfer. These activities are primarily site-specific and assist in determining the cleanup requirements and the resultant selection of cleanup technologies. This is high-priority work that offers scientists and engineers an opportunity to transfer the latest research knowledge directly to clean up actions. In addition, Superfund research entails a significant quality assurance and quality control (QA/QC) effort, designed to ensure that data are

documented and of acceptable quality. ORD provides control samples and oversees QA/QC throughout the Superfund Contract Laboratory Program.

This research strategy will describe the major informational gaps (data, methods, and technologies) that remain relative to Superfund site-specific risk assessments and risk reduction options. However, ORD develops similar or related methods and data in support of other Agency programs carried out under different statutes. The high-priority work identified in this plan will complement ongoing and future related work being conducted in support of the other non-Superfund programs. Where there is any overlap or similar relationship, it will describe how the work will be coordinated and result in appropriate and useful tools for Superfund site-specific risk assessments and risk management actions.

2.2 Relationship to Other Research

2.2.1 Grants Research

An additional aspect of the Superfund research program is its support of research grants on risk assessment and risk reduction to independent universities and research institutes. Specific research topics, chosen for their relevance to Superfund problems, are solicited through Requests for Applications (RFAs), which are issued as flyers and published in selected journals. Formal grant applications responding to RFAs are selected for support on the basis of technical peer reviews. In FY87, the Superfund Grants Program will issue two RFAs with the following titles: (1) development of technologies for the *in situ* treatment of hazardous materials and (2) development of measurement and monitoring methods. In both cases, projects will be supported for a maximum of three years. Projects will include new approaches, but for the most part will be adaptations of existing technologies. Emphasis will be on projects that have high potential for near-term applicability at Superfund sites.

2.2.2 Other Federal Research

SARA requires a comprehensive and coordinated Federal program of RD&D and training to support the Superfund cleanup effort. Research programs are authorized in two Federal agencies in addition to EPA: the Department of Health and Human Services (HHS) in health-related areas and the Department of Defense (DOD) in technology. Substantial coordination has occurred between all three agencies to ensure an integrated Federal research effort and to avoid duplication of effort.

Health-Related Research

Table 3 highlights the research and operational activities of EPA and HHS offices. The National Institute of Environmental Health Sciences (NIEHS) supports multidisciplinary biomedical research through grants to universities. EPA conducts applied research to detect, evaluate, or assess effects and risks to human health from hazardous substances. EPA's research program will focus on the development and evaluation of toxicological test methods, exposure assessment methodology, and risk assessment techniques. The Agency for Toxic Substances and Disease Registry (ATSDR) is authorized to conduct research related to its population-based health assessment responsibilities, which involve human exposure test methods, human health effects, epidemiological studies, site-specific health assessments, chemical-specific toxicological profiles, disease registries, and toxicological testing.

SARA does not clearly differentiate among research areas and agencies. Instead, each agency's program is centered on different areas related to its particular expertise: NIEHS supports basic university biomedical research; EPA conducts and supports applied research that will provide the information needed to assess risks at sites; and ATSDR conducts human population research and toxicological testing.

ORD, ATSDR, and NIEHS have taken steps toward coordinating research activities. Each agency's research plans have been circulated among scientists from the other agencies for review. Opportunities for collaborative research have been identified, as well as areas where close coordination of projects will be needed. The EPA Assistant Administrator for Research and Development, the Associate Administrator of ATSDR, and the Director of NIEHS plan to meet at least quarterly to discuss research plans and resolve issues.

Table 3. Superfund Health Research in EPA, NIEHS, and ATSDR

Basic Research		Applied Research		Operational Activities	
HHS/NIEHS	EPA/ORD	HHS/ATSDR	EPA/ORD	HHS/ATSDR	EPA
Biomedical	Monitoring	Epidemiological Studies	Animal Toxicology	Health Assessments	Risk Assessment/Risk Management
Interdisciplinary	Ecological	Health Surveillance Systems	Extrapolation Methods and Models	Toxicological Profiles	Technology Demonstration
Toxicological Studies	Engineering	Toxicological Testing	Risk Assessment and Characterization	Disease Registries	RI/FS
	Health	Human Exposure Assessment	Exposure Prediction and Modeling	Surveillance Systems	Response Actions
		Occupational Safety and Worker Health	Fate and Transport	Worker Protection	Enforcement
		Clinical Toxicology	Monitoring and Engineering	Risk Communication	

Technology-Related RD&D

SARA also authorizes Superfund RD&D in DOD to support its Environmental Restoration Program. A DOD and EPA working group was established in 1985 to explore cooperative research efforts that could be undertaken on hazardous waste technology. In 1986, the Department of Energy (DOE) joined the working group. While not directly authorized to conduct Superfund research, DOE is interested in cooperating on the development and demonstration of cost-effective and long-term solutions to hazardous waste problems that may be applicable to DOE facilities. Over 30 cooperative RD&D projects are currently underway as a result of this EPA, DOD, and DOE working group.

2.3 Roles and Responsibilities

While the Superfund research program is the responsibility of the Assistant Administrator for Research and Development, all Superfund resources remain the responsibility of the Superfund National Program Manager—the Assistant Administrator for Solid Waste and Emergency Response (OSWER) through the Director of the Office of Emergency and Remedial Response (OERR). This division of authorities is unique within the EPA research program, and requires extremely close cooperation and working relationships between ORD and OSWER managers and technical staffs.

2.3.1 Research Committee

ORD's research programs are guided by a combination of formal and informal input from program offices and Regions. The Hazardous Waste/Superfund Research Committee, one of six ORD/program office/Regional advisory committees to the Assistant Administrator for ORD, is jointly chaired by Office Directors representing ORD and OSWER. Three standing subcommittees—Superfund Research, Technology Transfer, and Hazardous Waste Research—are also jointly chaired by ORD and Program Office personnel. The Superfund research program is primarily coordinated by the co-chairs of the Superfund

Research Subcommittee, although the Technology Transfer and the Hazardous Waste Subcommittees are responsible for the integrated technology transfer programs and the Hazardous Releases research issues, respectively. The majority of hazardous waste research supports RCRA and HSWA, and will not be considered further in this document.

The Director of the Office of Environmental Engineering and Technology Development (OEETD) and the Director of the Office of Program Management and Technology (OPMT) are, respectively, the co-chairs for ORD and OSWER. Members and Subcommittee Co-chairs are shown in Table 4.

Table 4. Hazardous Waste/Superfund Research Committee

Office of Research and Development	Regions and Other Members	Office of Solid Waste and Emergency Response
John Skinner, OEETD, Co-Chair Fred Lindsey, OEETD Darwin Wright,* OEETD Jay Benforado,‡ ORD Tom Miller, ORPM/PCS Mike Callahan, OHEA Tom Hauser, OEETD/HWERL Richard Phillips, OHR/HERL Clint Hall, OEPER/RSKERL-Ada Cal Lawrence,† ORPM/CERI Bob Snelling, OADEMQA EMSL-LV *Co-Chair, Hazardous Waste Subcommittee ‡Co-Chair, Superfund Subcommittee †Co-Chair, Technology Transfer Subcommittee	Dan Beardsley, OPPE/OPA Lee DeHihns,* Region IV, CERCLA Oscar Ramirez, Region VI, RCRA *Contact:* Ralph Jennings	**Thomas Devine**, OPMT, Co-Chair Jeff Denit,* OSW Tom Pheiffer,† OPMT Ron Brand, OUST Elaine Davies, CEPP Frank Biros, OWPE *Co-Chair, Hazardous Waste Subcommittee †Co-Chair, Superfund and Technology Transfer Subcommittees

Superfund Research Subcommittee

The Superfund Research Subcommittee is composed of joint ORD/program office work groups, which have the day-to-day responsibility to ensure that: program office priorities are factored into research plans; extramural resource allocations reflect priorities; research results are conveyed to the Program and Regional Offices in a timely manner; technical issues between ORD offices, laboratories, and Program offices, are resolved expeditiously; and ongoing research projects reflect expectations and priorities. Generally, technical issues and priorities are resolved at the work group level; any potential deviations from Committee agreements, if approved by the Subcommittee co-chairs, are submitted in writing to the Committee co-chairs for approval. The applicable ORD office director(s), and the Office of Research Program Management (ORPM) may also be involved.

Historically, the work group organization parallels the budgetary issues (Table 1). However, this is by no means required, and the Subcommittee is considering possible alternatives and recommendations for a structure that enhances cross-office communications and more closely conforms to this plan.

Technology Transfer Subcommittee

The Technology Transfer Subcommittee is responsible for recommending priorities for technology transfer activities funded through the Committee, which include integrated technology transfer programs for hazardous waste, enforcement, and underground storage tanks, as well as Superfund.

Within the constraints placed on the use of trust fund monies, the Technology Transfer Subcommittee will seek to encourage activities that leverage among several program needs.

In addition, the Technology Transfer Subcommittee serves as an advisory body to OSWER, setting priorities for the Program Offices' resources. Since the Technology Transfer Subcommittee has representatives from six of the ten EPA Regions, it provides an excellent vehicle for directly addressing Regional needs.

2.3.2 Tracking

OSWER needs to know progress and interim results of ongoing research in order to plan its own regulatory and enforcement agenda and to ensure that field office staffs have the most current information available. ORD will provide OSWER with project-tracking information commensurate with the level of the research activity defined by the Research Committee. In general, this means below the level of the planned program activity (PPA), but may aggregate laboratory projects or tasks.

The ORD Subcommittee co-chair ensures that program office counterparts receive adequate information on research progress. As a routine matter, the Program Coordination Staff (ORPM/PCS) generates and transmits quarterly progress reports for each PPA to the OSWER co-chair. However, the ORD and OSWER Work Groups will ensure that significant events are immediately communicated, and any changes in schedules, products, or resources are coordinated as they occur.

3. RISK ASSESSMENT RESEARCH

This section of the research program strategy discusses the environmental and health risk assessment research program. To begin the new RD&D program, two priorities will be emphasized: development of health effects data and methodologies and their application to human health risk assessment methods; and total exposure methods. The program will focus on:

- New or improved sampling protocols and analytical methods to characterize sites as well as wastes at sites;
- Methods to determine the "populations at risk" at Superfund sites;
- Methods to determine the routes of, and extent of, exposure to wastes at sites;
- Methods to determine the adverse health effects in populations exposed to hazardous substances; and
- Risk characterization methodologies, including calculation of the incidence of adverse effects in exposed populations.

3.1 Objectives and Goals

The goal of health effects research is to provide laboratory and field observations of adverse health effects and exposures to chemicals. Risk assessment research provides qualitative and quantitative predictions of human health effects from these exposures and provides a credible basis for regulatory actions. EPA's risk assessment methodologies include four broad components: hazard identification; dose-response assessment; exposure assessment; and risk characterization. The quality and scientific certainty of site assessments are contingent on these components. The research program provides data, toxicological assistance, and methods in all four areas.

Research on human health risks is planned around several major toxicological data needs: risk characterization methods (hazard identification, dose-response assessment, and exposure assessment) for noncancer endpoints and quantitative links of monitored concentrations to delivered dose to target bioreceptors; techniques to extrapolate from high to low dose, route to route, and animals to human; structure activity relationship (SAR) methods; statistical methods to describe uncertainties and *in vivo*

and *in vitro* methods to enhance health effects data on site-specific priority chemicals. Additional research on exposure will include techniques for monitoring human populations, biological markers, pharmacokinetics and total body burden, advanced biological methods, exposure monitoring systems, and episodic exposures.

To plan the health-related and risk assessment research program ORD and OERR independently identified research needs. OERR prepared a list of research and technical information needs based on a survey of regional staff and their contractors, while ORD identified the scientific gaps that hinder the assessment of Superfund sites. These parallel efforts were merged and resulted in the final program framework for FY87 and FY88 as described in detail below.

3.2 Risk Characterization

To augment the Agency's existing risk characterization ability, this effort will focus on estimating the incidence of adverse health effects in populations exposed to hazardous substances. Basic and applied research will include direct site assessment support activities, rapid-response toxicity testing, and toxicological evaluation associated with control technologies. Additionally, research will be conducted on the nature and magnitude of toxicological interactions associated with multimedia exposure to chemical mixtures.

3.2.1 Site Assessment Support

The accuracy of site assessments in the Superfund program predominately controls the quality of risk-based decisions. This research effort is directed at reducing the uncertainties in extrapolation techniques (high to low dose, animals to human, route and duration exposure, and species sensitivity), as well as patterns of toxicologic interaction for multimedia and multichemical exposures. To enhance the scientific rationale supporting the reliance on these tools, an integrated approach of data survey, testing, and analysis will be used.

Site assessment research represents a microcosm of health and risk assessment research issues. Exposure assessment, including transport and fate; chemical-specific hazard identification for less-than-lifetime and route-specific exposure; sensitive subpopulations; and post-remedial residual risk assessment are all fundamental components of technically defensible site assessments. The ability to characterize the identity and level of contaminants present is integral to the assessment of a site. Chemical and newly developed screening techniques will provide detailed data from which risk assessments can be based.

3.2.2 Chemical Mixtures

EPA begins its health risk assessment process by evaluating risks from specific chemicals and extrapolating that information, to the extent possible, to the mixtures found at Superfund sites. These sites typically contain complex mixtures of many different compounds and their degradation products, all of which exist in more than one physical phase. The current approach—using indicator chemicals to assess risk at sites—does not quantitatively assess possible toxicant interactions that may occur in such complex mixtures.

This research will focus on improving risk assessment techniques for situations involving complex mixtures through: investigation of dose-additivity methods for assessment of mixtures of systemic toxicants; validation of risk-additivity methods for assessment of mixtures of mutagens and carcinogens and nonmutagens and noncarcinogens; use of methods such as structure-activity relationships (SARs) to account for mixtures of highly variable composition (variations in space or time, or wastes that contain poorly studied components); and assessment of partial-lifetime exposure to complex mixtures.

3.3 Exposure Assessment

Exposure assessment—estimating the concentration of a pollutant at the point of receptor contact—typically entails the use of mathematical modeling of transport and fate. Environmental moni-

toring data can provide a more direct measure of exposure, and are used when available to complement modeling.

Exposure assessment methodologies have developed rapidly in recent years; however, additional research is needed to refine models especially in terms of transport mechanisms that vary by site. Over the next five years, there will be increasing need for better data and refined methods to reduce the inherent scientific uncertainties.

Direct measurement of human exposure has been done using personal air monitors, on tap water, food and beverages, and even skin absorption. Body burdens have been measured using exhaled breath, blood, and adipose tissues. These methods are presently available for certain groups of chemicals, such as volatile organic compounds (VOCs), metals, and pesticides, but they need to be developed for other important groups, such as polyaromatic hydrocarbons, dioxins, and furans. Field studies of exposure of residents near hazardous waste sites are possible for VOCs; an initial screening using breath sampling could select sites that require follow-up environmental monitoring.

Exposure assessment in the context of adverse human health effects is the determination or estimation of that dose or concentration of a chemical pollutant delivered to the target organ. Health effects assessment methods will address this subject.

3.3.1 Pharmacokinetics and Metabolism

A major pharmacological and toxicological need is to base risk estimates on concentration or dose of a chemical actually eliciting an effect at the target organ, rather than on concentrations found in the environment or applied dose. The goal of this research will be to extend exposure assessment capabilities to internal target sites which will contribute significantly to more accurate and reliable estimates of risk.

Pharmacokinetics (PK) describes the rate of the disposition of a chemical and its metabolites in the body. Physiologically based PK models are mathematical descriptions of such disposition, and will help Superfund exposure assessments in several ways: to predict tissue deposition from one exposure regimen to another; to predict tissue concentrations from species in which experimental data exist to those species where data are unavailable; and to compare the effect that alterations in metabolic pathways and rates have on internal disposition.

3.3.2 Biomarkers

A "biological marker" is any biological measurement made that can be used to estimate the extent of exposure of an organism or to provide an indication of an adverse health effect caused by exposure to hazardous substances. The goal of biological marker research is to develop and utilize these techniques to determine the rate of uptake of chemicals in the body and to determine the relationship between chemical dose and observed health effects.

Biological marker research will substantially improve quantitative risk estimates made at Superfund sites and will enable more precise exposure estimates, currently a major component of uncertainty. Biological effect markers will improve the ability to predict onset of adverse health effects.

3.3.3 Environmental Assessment

Environmental assessment research addresses the physical determinants of human exposure, and is closely related to complementary work under the site assessment category. The five-year research program will collect empirical data for physical-chemical properties, measurement of partitioning characteristics in the environment, field testing and calibration of transport and fate models, analysis of dispersive vectors for transfer of pollutants to humans, development of methods to estimate human intake rates of chemicals by multimedia exposure pathways, and development of a data base handbook on exposure assessment parameters.

3.4 Health Assessment

Health assessment research is designed to improve the accuracy of health risk estimates associated with chemical-specific exposures at Superfund sites. Research will provide new data and rapid, cost-effective methods for screening chemicals for toxicity. The research program will also provide comparative potency data for risk estimates of priority chemicals and complex mixtures. Initial emphasis will be on neurotoxicity, reproductive toxicity, mutagenicity and carcinogenicity, target-organ toxicity, including hepatotoxicity and pulmonary toxicity. Much of the work will involve acquisition of data in test mammalian and nonmammalian species and humans with common exposures, which will also permit improvement in interspecies extrapolations.

3.4.1 Reproductive Risk Assessment

Adverse effects on human reproduction is a principal concern at many Superfund sites and methods are needed to enable a thorough examination and quantification of reproductive risks. Coordinated laboratory and field investigations will be performed to facilitate assessment of reproductive and development risks at hazardous waste sites. This research will enhance OERR's ability to rapidly evaluate reproductive risks, based on available data, for specific chemicals found at sites. The research activity will focus on specific chemicals found at sites.

3.4.2 Neurotoxicology

Scientific understanding of, as well as public concern about, neurotoxic effects of chemicals has grown in recent years. By capitalizing on recent scientific advances, applied research for the Superfund program will produce more sensitive, specific, and efficient methods for assessing risks of human exposure to neurotoxic chemicals and extrapolating toxicant-induced neurological disorders from animals to humans.

3.4.3 Carcinogenicity

One of the key health effects of concern from exposure to hazardous substances is cancer induction. Even though scientists do not understand the mechanisms of cancer, the massive amount of basic cancer research has identified important parameters that EPA can use in assessing cancer risks at Superfund sites. Currently, however, risk assessment methods and approaches do not maximize the use of available scientific information. There have been rapid changes in the understanding of carcinogenesis, requiring continual revisions to risk assessment methods. At the same time, new approaches are needed that will increase the understanding of molecular, cellular, and pathological aspects of carcinogenesis and pharmacokinetics to better estimate the risks of exposure to environmental carcinogens.

The ORD research program is currently focusing on the development of biologically based models for carcinogen risk assessment, use of pharmacokinetics for dose extrapolation, methods to express uncertainties, animal-to-human extrapolation methods, and the generation of specific data for particular chemicals to reduce uncertainties in carcinogen risk assessment.

3.4.4 Immunotoxicology

Recent research involving testing of components of immune system functions indicates that a variety of chemicals found in the work place and environment depress immune responses. The immune system plays a vital part in maintaining human health by protecting the body from foreign substances; therefore, the relationship between environmental chemical exposure and the integrity of the immune system is of great importance, especially in alterations of host-defense mechanisms.

Research in immunotoxicology will focus on identifying an array of available tests and models that would effectively identify and predict risks to humans.

3.5 Expected Accomplishments

Over the next five years, the Superfund research program in risk characterization will directly support site assessment activities in a number of areas, with anticipated results providing: (1) health data and methods for toxicological effects of priority chemicals; (2) risk assessment techniques for partial-lifetime exposures needed for temporary contamination episodes, coupling exposure assessment and epidemiology, and reviews and updates of approaches used in interspecies conversion of dose and duration; (3) methods to extrapolate toxic-effect levels between routes of exposure, estimate total hazard following multiple exposures, and protect sensitive subgroups (age, genetic predisposition to disease) currently not identified in Superfund risk assessments; (4) review and improvement of acceptable daily intake calculation methods; (5) coupled source and personal monitoring to discriminate among possible sources of pollutants and between background and anthropomorphic levels; (6) new multi-analytic chemistries for site characterization; (7) real-time monitors and field screening techniques for priority chemicals; and (8) methods to account for highly variable mixtures and the assessment of partial-lifetime exposures to complex mixtures.

During this time, exposure assessment research will result in better and more methods to assess absorption across pulmonary, dermal, and placental membranes; integration of existing global, organ-specific, and cell-specific pharmacokinetic models developed using data from other exposure pathways to predict targets for use on dose-response functions; long- and short-term metabolic effects and human metabolic rate constants for humans from in vivo studies; and an assessment of the expected variation in metabolic rates and patterns resulting from genetic differences. Biomarkers may be developed to substantially improve population-selection criteria for epidemiological studies that usually form the basis for quantitative risk estimates.

Health research will develop and evaluate the techniques required for RI/FSs on reproductive risk, neurotoxicity, and carcinogenicity of chemicals of concern. Within five years, health research will have evaluated various approaches for estimating teratogenic risk; reproductive toxicity endpoints for risk analysis and approaches for evaluating severity of response; fetal toxicity relative to maternal toxicity; multigeneration data; and currently available infertility tests for risk assessment.

4. RISK REDUCTION RESEARCH

Risk due to pollutants at Superfund sites can be reduced in three ways: the pollutant source can be removed, treated, and disposed elsewhere; exposure can be minimized; and control technologies can be applied at the site to detoxify, destroy, or immobilize hazardous constituents.

The research and development program is targeted primarily on the efficacy of control technologies in reducing contamination and risk. The other risk reduction options (source removal and exposure control), while used in the past, are now generally considered less desirable than methods that reduce toxicity and mobility. Under SARA, EPA must select remedial measures that emphasize permanent solutions, and utilize alternate treatment technologies where practical and cost-effective.

4.1 Goals, Objectives, and Approach

The overall goal of the Superfund risk reduction research is to ensure the availability of effective technology for the cleanup of hazardous waste sites that pose an unacceptable risk. To meet this goal, the program has 10 research objectives, the last five of which concern the development of new or improved treatments:

1. To permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes;

2. To provide *in situ* treatment of contaminated surface soils and unsaturated soils;

3. To clean up contaminated ground water;

4. To contain hazardous wastes on site or provide for ultimate disposal of treatment residuals;

5. To protect the personnel involved in site assessment and cleanup;

6. To demonstrate innovative technologies for the cleanup of Superfund sites;

7. To expedite availability of innovative and alternative technologies;

8. To provide information on new treatment technologies for the benefit of EPA, State, and private-sector decisionmakers;

9. To develop improved analytical, chemical, or biochemical detection technologies to assess the effectiveness of remediation on treatment;

10. To encourage private-sector development of appropriate technologies.

The Superfund program is largely an operational program. Superfund is a technology user, and this places emphasis on research, development, and demonstration programs designed to fill technology needs. Agency decisionmakers need information on the performance and cost of technologies so that trust funds can be directed effectively. With the exception of certain forms of incineration and chemical fixation, cost-effective permanent technologies have not been fully tested on all important combinations of wastes at Superfund sites and materials containing these wastes.

The risk reduction program is divided into two complementary areas. One area encompasses an EPA-funded effort to develop new or improved control and treatment technologies both in house and through extramural projects. A number of technologies have been developed in this way, such as the EPA mobile incinerator and mobile soil washer. EPA has found it necessary to actively develop technologies because of the lack of adequate development by the private sector.

The other major area related to Superfund technology is the SITE program (Superfund Innovative Technology Evaluation), an effort to expedite the development and commercial availability of alternative technologies developed by the private sector. The goal of the program is to remove the informational, regulatory, and institutional impediments to new technology development and commercialization efforts. There are two major RD&D components to this program:

- A demonstration program for developed treatment and site assessment technologies that provides credible performance and cost-effectiveness information developed at full-scale using actual Superfund wastes;

- An evaluation program for emerging treatment and site assessment technologies designed to provide technical advice to the private developer and, where necessary and appropriate, support continued development.

Both of these subprograms include extensive technology transfer and technical assistance efforts.

4.2 New or Improved Technologies

Agency efforts to develop and adopt technologies are divided between site surface cleanups and ground water cleanups.

4.2.1 Technologies for Site Surface Cleanup

Surface wastes, such as waste lagoons, barrels, or sludge piles, can be excavated and moved to the treatment equipment for detoxification. These technologies will be referred to as "surface equipment technologies." If the wastes have penetrated below the surface, it may be more desirable to treat the waste in place (*in situ* treatment). A surface lagoon could also be treated in place, as opposed to moving the waste to a treatment unit.

For both the surface equipment and *in situ* treatment technologies, five major processes are being addressed:

- Extraction processes, which separate contaminants from the media in which they are found. The development of field-usable systems for separating contaminated soils into its fractions could minimize on site treatment and disposal costs.

- Immobilization processes, which permanently bind a contaminant to the existing medium or to a modified medium.

- Detoxification processes, which detoxify, degrade, or destroy the contaminants in the hazardous waste. The most common detoxification processes include biological, chemical, and thermal techniques. Studies of alternative technologies being conducted under the Resource Conservation and Recovery Act (RCRA) will be extended to the wide diversity of Superfund hazardous substances and contaminated residuals. Tests will establish process applicability, feed, and waste preparation requirements, ability to meet the RCRA best demonstrated available technology requirements, and determine residue quality.

- Delivery and recovery processes, essential elements of most *in situ* treatment technologies, are required to deliver the "treatment medium" to the source of contaminants, and, if necessary, recover the contaminants for further treatment. They remain the biggest engineering obstacle to actual implementation, because actual systems have not been applied frequently to hazardous waste problems. Waste-site feeds are highly variable, thus feedstock handling, preparation, and introduction into the incinerator are a major concern.

Table 3 provides more information on the specific technologies that are being developed or evaluated. One additional category is field monitoring equipment, including:

- Screening technologies for environmental monitoring, which provide rapid cost-effective measurements in the field. The most promising screening technologies include X-ray fluorescence, field-gas chromatography, immunochemical methods, and fiber-optic sensors.

4.2.2 Technologies for Ground-Water Cleanup

The cleanup of ground waters contaminated by Superfund hazardous wastes is a difficult technical problem. Two alternative approaches for cleanup of polluted ground water are available—pump-treat-recharge and *in situ* treatment.

Pump-Treat-Recharge

In this approach, the ground water is pumped to the surface, treated to remove the pollutants, and then injected either back to the ground water or to surface waters. Conventional water supply treatment technologies are available to treat contaminated ground water that has been pumped to the surface. Appropriate sludge handling and disposal will be required to treat any sludges. Superfund research in this area is limited but may be reexamined as new technologies or approaches are identified.

In Situ Treatment

In situ restoration of polluted ground water is a complex operation. Current research is examining ways of making *in situ* restoration techniques less expensive and more easily applicable. Biodegradation of contaminants is one of the most promising techniques. An *in situ* process utilizing microorganisms to degrade specific contaminants could be a more economical and effective treatment.

Initial success in the laboratory has been achieved for the biodegradation of trichloroethylene (TCE), PCBs and several other compounds. Research is continuing on biodegradation, with substantial emphasis

Table 3. Technologies for Site Surface Cleanup

	In Situ	On Site
Extraction	Evaluation of artificial freezing of contaminated soils; vapor phase soil decontamination (soil flushing, biodegradation, vacuum removal), colloidal gas aphron technology, and electrokenetic extraction.	Field demonstration of the EPA Soils Washing System; removal of lead, other inorganics, trichloroethylene, and other volatile organics from soils and sediments. Laboratory studies to improve technology of extracting organics with surfactant and chelation agents. Investigation of mining separation techniques.
Immobilization	Evaluation of solidification and stabilization, grouting, precipitation, and thermal fusion (vitrification).	Temporary containment of contaminated materials prior to extraction, immobilization, degradation, or detoxification. Fixation and stabilization will be evaluated with emphasis on equipment that can be used on site. Improved techniques and options for waste containerization and storage will also be initiated. Immobilization processes are used primarily for the treatment of surface lagoons.
Degradation and Detoxification	Applications of permeable treatment wall systems, full-scale building decontamination techniques; increased emphasis on promising *in situ* biological processes.	Test burns and related compliance and operational activities at CRF in support of Superfund site cleanup activities. Pilot-scale incinerators will be used to incinerate samples of residues to determine waste-handling and feeding requirements, operating conditions for maximum efficiency; air pollution control requirements; and to assess incineration residues. Demonstrate Mobile Carbon Regenerator will be demonstrated under full-scale field conditions to reactivate spent carbon from a physical/chemical treatment system; Continue to develop potassium polyethylene glycol (KPEG) detoxification process and white rot fungus biological process.
Delivery and Recovery	Evaluate the effectiveness of systems to deliver extraction, immobilization, or detoxification agent to site and recover it with the pollutant.	Evaluate techniques to improve incinerator feedstock handling procedures so that commercial on-site incineration systems can be used at minimum cost.

on the adaptation of processes for *in situ* cleanup (biosystems). Future laboratory and field studies will be initiated to assess the effectiveness of *in situ* cleanup, leading to *in situ* cleanup protocols.

4.3 SITE Program

The purpose of the SITE program is to remove obstacles to the development and routine use of alternative or innovative technologies developed by the private sector. This involves a demonstration program, a development program, and an impediments removal program.

4.3.1 Demonstration Program

Probably the most serious barrier to routine use of alternative or innovative treatment and site-assessment technologies in Superfund cleanup is a lack of credible, full-scale information on the performance and cost-effectiveness of these technologies. EPA decisionmakers are reluctant to use these technologies when they have not been "proven in the real world." To develop this kind of information, the technology must be demonstrated at full scale on Superfund wastes. Under the SITE program, private developers can operate their commercial-scale equipment on Superfund wastes and most will be demonstrated at Superfund sites. EPA will monitor and evaluate the tests and report the results. The cost-effectiveness of the technologies will be extended to other wastes and other Superfund situations as guidance for EPA and other decisionmakers. SARA §311(b) requires that EPA conduct at least ten such demonstrations a year.

EPA began implementation of the program in early 1986 with a *Commerce Business Daily* advertisement asking interested private developers to participate. As a result, EPA is currently working with the owners of ten innovative technologies to arrange demonstrations during 1987. To identify additional technologies for 1988 demonstrations, another advertisement was issued in January, 1987.

4.3.2 Development Program

As part of the SITE program, EPA will sponsor an evaluation and support program to encourage private-sector technology development. A pilot- and bench-scale evaluation effort will be the cornerstone of this program and will be conducted similarly to the demonstration program. Developers will operate their equip-ment; EPA will provide wastes and conduct the evaluation. EPA expects to evaluate between 15 and 25 such technologies annually starting in FY88. To expedite these evaluations, EPA intends to develop a test and evaluation (T&E) facility in Edison, New Jersey.

Some technologies are developed by small firms lacking the resources to commercialize their developments expeditiously. For a particularly promising technology, EPA may directly support further development. Typically, this will not be considered until after an evaluation. Thus, no development support projects are envisioned until late in FY88.

4.4 Personnel Protection

One way of reducing the risk to personnel directly involved in the Superfund cleanups is to provide the personnel with protective clothing and equipment. ORD has worked with EPA personnel and private industry to evaluate technologies applicable for personnel to use during removal and remedial activities. Evaluations of protective clothing, breathing apparatus, and personal hazard detectors will result in data and information to support what should be provided and how it should be used. Procedures are also being developed for the decontamination or disposal of protective clothing and associated equipment.

Future activities will include the evaluation of personal cooling devices and vital-signs monitoring devices under actual field conditions. These activities are focused upon increasing the safety, efficiency, range, and cost-effectiveness of cleanup operations at hazardous waste spills and at Superfund sites.

4.5 Related Work

The development of risk reduction technology for Superfund sites is similar to the development of control technologies for other environmental problems. The closest related area is the technology needed under RCRA for treatment of hazardous wastes and for correcting environmental problems associated with existing hazardous waste land disposal facilities. The Superfund research program will utilize the RCRA-related alternative technology research program to gather information on their performance in treating Superfund wastes. As the various technologies are being evaluated on RCRA wastes, additional tests will be scheduled with selected Superfund wastes.

A second area in which complementary work is underway is the development of personnel protection technology, although the activities are being phased down. Because EPA's pesticides and

toxic substances programs also need such technology, a combined research plan has been developed. The objectives of this program are to:

- Develop and evaluate chemical protective clothing and equipment;
- Develop and evaluate procedures to provide safe working environments;
- Develop and verify methods to predict the effectiveness of chemical protective clothing;
- Develop and evaluate hazard detection methods and equipment;
- Ensure that all data are of known quality and acceptable for their intended use.

4.6 Expected Accomplishments

The major products in the area of technologies for on-site and *in situ* cleanup over the next few years include reports or handbooks on survey and assessment of completed and ongoing remedial actions; leachate treatment techniques; assessment of international hazardous waste technologies; on site cleaning of equipment; *in situ* treatment of hazardous waste contaminated soils; and selected assessment of on site stabilization/fixation methods. Additional user-friendly applications, such as expert systems, will be made available to allow on-scene and field office personnel rapid access to complicated databases.

A major focus will be on the development and demonstration of biological treatment systems (biosystems). The research program will also enable newly developed monitoring processes to be demonstrated as feasible to Superfund issues. Applicable technologies will then be developed, evaluated, and validated. Considered in the program will be biological methods (immunoassays), physical methods, such as fiber-optic sensors and x-ray fluorescence, and expert systems to provide real-time data analysis in the field.

Research bearing on ground-water cleanup will produce reports and technical articles on bench-scale demonstration of feasibility for *in situ* biodegradation of TCE, and will develop procedures for biological cleanup of TCE-contaminated areas and enhanced biorestoration of contaminated ground water.

The SITE demonstration program will follow the SITE strategy and program plan with series of reports on each technology, and will develop and maintain the Superfund Technology Clearinghouse.

Personnel protection research will produce reports and handbooks evaluating personnel hazard detection for highly toxic chemicals, on the performance of personal cooling devices, and on personnel health and safety procedures in specific situations.

5. TECHNICAL SUPPORT

ORD also provides nonresearch support to the Superfund program that is critical to the day-to-day success of Superfund cleanup activities. The technical support program involves the scientists and engineers working on the risk assessment and risk reduction RD&D, and ORD's Center for Environmental Research Information.

The overall goal of the Superfund technical support program is to provide the Program Offices, Regional Offices, states, and private industry with the technical expertise and current information necessary to implement the Superfund risk assessment and risk reduction process, and to operate the day-to-day program of providing enforcement support to the Regions. The objectives of the program are to:

- Provide direct technical services to support the site-specific assessments;

- Provide scientific and engineering expertise to support the site-specific risk assessment and reduction;
- Provide data and protocols for risk assessments and risk reduction activities;
- Conduct a comprehensive training and technology transfer program;
- Conduct other Superfund-related programmatic activities to support the RD&D program;
- Ensure that all data are of known and acceptable quality.

5.1 Technical Services

5.1.1 Quality Assurance

Sound risk assessment and risk reduction decisions depend on data of known and documented quality. The primary responsibility of the Superfund quality assurance (QA) program is to ensure that the analytical data produced by EPA and its Contract Laboratory Program (CLP) are of known and documented quality. A second responsibility is to provide QA support to the Regional and ORD laboratories.

QA support is provided for 15 analytical methods, over 75 individual laboratories, the analysis of 60,000 to 80,000 samples per year, QA audits of potential contractors prior to their selection, QA audits to evaluate the performance of contract laboratories, provision of standard materials for calibration of analytical methods, and evaluation and improvement of analytical methods for additional types of waste or waste matrices. QA support activities will be expanded to provide for an additional 15 to 30 analytical methods and additional contract laboratories as required.

Research will be initiated to determine the effects that sampling protocols, handling, and shipping have on final data integrity. The goal of this research is to identify those areas, outside the laboratory, where data integrity may become compromised, and to provide a protocol to eliminate the uncertainty. Research emphasis will be on the standardization of procedures, field audits, and laboratory materials used in the field-sampling process.

5.1.2 Reportable Quantities

The overall objective of this area is to provide the necessary health effects documentation for determining reportable quantities (RQs) for substances proposed for listing as hazardous wastes or on the Acute Hazards List under RCRA. SARA requires that an RQ be prepared for every chemical listed under RCRA, and EPA anticipates that this effort will be substantially completed in FY89.

5.1.3 Site-Specific Risk Assessments

Program and Regional offices often request ORD to prepare site-specific, chemical-specific, or situation-specific exposure and risk assessments to evaluate the hazard and remediation or regulatory options available for Superfund sites. These include carcinogenicity profiles for compounds on the original CERCLA substances list, rapid-response health assessments, and assistance to ATSDR in preparing toxicological profiles.

5.1.4 Remote Sensing and Aerial Photography

Remote sensing and aerial photography provide valuable information in pre- and post-remedial site assessments. Some newer techniques will be added that offer greater cost-effectiveness, including multispectral scanners and other passive systems, laser fluorosensors, differential absorption, and other technologies. ORD provides this service to the Regional Offices, OERR, OWPE, and EPA contractors as needed.

5.2 Scientific and Engineering Expertise

5.2.1 Enforcement Support

SARA strengthens EPA's enforcement responsibilities and formalizes procedures for negotiating settlements with PRPs. ORD provides scientific and engineering expertise, as requested, to review risk assessments and remedial action plans. ORD experts provide assistance for enforcement-case preparation and may serve as expert witnesses. Major enforcement support activities include:

- Monitoring support for case preparation, compliance monitoring, and development of settlement agreements;
- Geographical mapping to locate subsurface anomalies and trace leachate plumes;
- Engineering technical advice and consultation on emergency and remedial response options;
- Technical support for the application of site-specific ground-water models;
- Peer-reviewed endangerment assessments and brief hazard summaries for use in negotiation and litigation.

5.2.2 Remedial Action Support

The cleanup of Superfund sites requires a remedial investigation/feasibility study (RI/FS) and a Remedial Action Plan. ORD provides direct scientific and engineering support to the program and Regional Offices, upon request, to assist in reaching an acceptable permanent solution for each site. This direct technical support is provided by the same scientists and engineers who conduct the Superfund research. Consequently, ORD will provide state-of-the-art data, methods, and technologies for consideration in cleanup plans.

The major remedial action support activities include:

- Site-specific monitoring;
- Site-specific quality assurance;
- Site-specific engineering and scientific advice on cleanup options;
- Site-specific evaluations of cleanup technologies;
- A multidisciplinary team of ground-water specialists;
- Technical support on marine contamination from coastal sites;
- Technical support on application of multimedia risk assessment methods.

5.3 Training and Technology Transfer

The Superfund RD&D program produces an enormous amount of scientific and engineering information, which must be synthesized, interpreted, organized, packaged, and disseminated to EPA Program and Regional Offices, states and local governments, contractors, PRPs, and the public. ORD has a very active technology transfer program that will be expanded from FY87 to FY91. While ORD does not sponsor training, *per se*, it supports the program offices through the development and integration of automated systems into computer-assisted instruction, expert systems, and databases.

ORD and OSWER developed a joint *Technology Transfer Strategy* (April, 1987) that describes the systematic process for identifying needs, disseminating information, and evaluating their results. A key organizational element of the *Technology Transfer Strategy* is the Technology Transfer Subcommittee,

which serves a dual role as a standing subcommittee of the Hazardous Waste/Superfund Research Committee and the advisory body to OSWER in setting program office priorities for technology transfer activities.

The training and technology transfer activities within the Superfund RD&D program will conform to the OSWER Technical Training Policy as well as the *Technology Transfer Strategy*.

The selection of appropriate, cost-effective innovative or alternative treatment technologies to clean a specific hazardous waste spill or Superfund site involves a complex decisionmaking process. Using microcom-puters, expert systems offer an opportunity for a real-time problem-solving capability. Unlike manuals or seminars, expert systems provide direct help to decisionmakers in the development of cleanup options for Superfund sites. They provide clear, concise, and structured approaches based on the latest data. Continuous maintenance of expert systems is mandatory, however, to ensure that the latest information is available from the research community, other users, and industry to complement information provided on site.

Work on expert systems must accompany the technology RD&D program to ensure that the necessary data are collected for the decisionmaking process. The data requirements for the expert systems must be identified before testing begins in the RD&D phase. Working with Program Office representatives and the Office of Information Resources Management, the Superfund research program will ensure that expert systems are designed with appropriate safeguards to prevent their misuse.

5.4 Expected Accomplishments

Technical services will continue to grow in relative importance and effort over the next several years. The QA program will develop procedures to identify and investigate deliberate fraud in the CLP. Investigatory procedures will be evaluated for reliability in identifying fraud and mismanagement, and an investigative QA protocol will be developed. Through its completion by FY90, the reportable quantities program will produce RQ chapters in chemical-specific health and environmental effects documents (HEEDs), RQ documentation for carcinogenicity or chronic toxicity for chemicals from the Extremely Hazardous Substances List, and additions or revisions as needed in the future to meet statutory requirements.

Scientific and engineering expertise will continue to be available on a person-to-person basis, although the trend is towards expert systems and other computer-based methods for training and technology transfer. ORD will develop and maintain a clearinghouse for information on remedial actions, technologies, analytical methods, and case histories.

6. RESOURCES

The historical funding of the Superfund RD&D program is presented in Table 5. The Agency has developed detailed budgets for FY87-FY88, which include increased resources for the new SARA research authorities, and is currently preparing a budget request for FY89. Table 6 presents the distribution of resources by ORD office, program category, and budget issue. The major areas of expansion are the new health effects and risk assessment research program, exploratory grants, and the SITE program.

For FY88, the President's Budget includes additional resources for health effects and risk assessment research and the SITE program. Funds are also included in the FY88 request for renovation of a T&E facility where Superfund wastes and treatment technologies would be evaluated.

Table 5. ORD Superfund Resources

Intramural and Extramurnal Dollars

Fiscal Year	FTEs	Total ($ Millions)
81	7.6	5.0
82	26.6	13.8
83	27.1	6.8
84	42.5	8.9
85	58.0	12.6
86	57.6	10.6
87	85.6	38.7
88*	85.6	58.8

*President's Budget.

Table 6. Superfund Research Resources by Program Area

(Total Resources in Thousands)

Issue	Risk Assessment		RiskReduction		Technical Support	
	FTEs	$000	FTEs	$000	FTEs	$000
Site and Situation Assessment						
FY87:	17.9	$4,948.5				
FY88:	17.9	$4,865.0				
Health Effects/Risk Assessment						
FY87:	5.0	$6,770.8				
FY88:	5.0	$9,991.4				
Technology Evaluation						
FY87:			19.3	$6,583.3		
FY88:			19.3	$5,704.5		
Innovative and Alternative Technology RD&D (SITE)						
FY87:			8.0	$9,070.9		
FY88:			8.0	18,629.4		
Personnel Protective Equipment						
FY87:			2.0	$714.3		
FY88:			2.0	$725.3		
Test and Evaluation Facility						
FY88:				$5,600.0		
Reportable Quantities						
FY87:					2.7	$698.1
FY88:					2.7	$829.6
Technical Support						
FY87:					20.7	$5,678.3
FY88:					20.7	$7,044.2
Quality Assurance						
FY87:					9.0	$3,784.9
FY88:					9.0	$4,796.8
Technology Transfer						
FY87:					1.0	$432.8
FY88:					1.0	$625.8
Subtotals (FY87):	22.9	$11,719.3	29.3	$16,368.5	33.4	$10,594.1
Subtotals (FY88):	22.9	$14,856.4	29.3	$30,659.2	33.4	$13,296.4
Total (FY87):	85.6	$38,681.9				
Total (FY88):	85.6	$58,812.0				

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